DOCUMENT RESUME

ED 152 597 SE 024 163

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TITLE Turbidity. Training Module 5.240.2.77.
SPONS AGENCY Department of Labor, Washington, D.C.; Iowa State Dept. of Environmental Quality, Des Moines.
PUB DATE Sep 77
NOTE 30p.; For related documents, see SE 024 138-165; Contains occasional light and broken type in transparency masters

EDRS PRICE MF-$0.83 HC-$2.06 Plus Postage.
DESCRIPTORS *Instructional Materials; *Laboratory Techniques; *Post Secondary Education; Secondary Education; *Teaching Guides; Units of Study
IDENTIFIERS *Turbidity; *Water Treatment

ABSTRACT

This document is an instructional module package prepared in objective form for use by an instructor familiar with candle turbidimeter and the nephelometric method of turbidity analysis. Included are objectives, an instructor guide, student handout, and transparency masters. A video tape is also available from the author. This module considers use of the candle turbidimeter, the nephelometric turbidimeter, preparation of standards and calculation of results. (Author/RH)

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ED152597

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TURBIDITY

Training Module 5.240.2.77

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The publication of these training materials was financially aided through a contract between the Iowa Department of Environmental Quality and the Office of Planning and Programming, using funds available under the Comprehensive Employment and Training Act of 1973. However, the opinions expressed herein do not necessarily reflect the position or policy of the U. S. Department of Labor, and no official endorsement by the U. S. Department of Labor should be inferred.

September, 1977

SE 024 163

Module No:	Module Title: Turbidity
	Submodule Title:
Approx. Time: 3.0 hours	Topic: Summary

Instructional Objective:

Upon completion of this module the participant should be able to:

1. Determine the turbidity of water in Jackson Turbidity Units.
2. Determine the turbidity of water in Nephelometric Turbidity Units.
3. Choose the appropriate method for a given sample.

Instructional Aids:

Transparencies Tu1 - Tu5 - Surface water analysis videotape

Instructional Approach:

Lecture, discussion, laboratory practice, videotape viewing

References:

1. Standard Methods for the examination of Water and Wastewater, 14th ed.
2. Operator's manual for turbidimeter

Class Assignments:

Module No:	Module Title: Turbidity
Approx. Time: 0.25 hours	Submodule Title: Visual Method
	Topic: Water Clarity

Instructional Objective:

Upon completion of this module the participant should be able to:

1. Identify sources of turbidity in water.
2. Give a definition for turbidity.
3. Explain why samples should be agitated prior to testing.

Instructional Aids:

Transparency Tul - definition of turbidity.

Instructional Approach:

Lecture, disucssion.

References:

Standard Methods pp. 131, 132.

Class Assignments:

Module No: Tu	Topic: Water Clarity

Instructor Notes:	Instructor Outline:
	1. Turbidity sources - suspended matter a. clay b. silt c. organic and inorganic matter d. plankton e. other micro-organisms
Transparency Tu-1 Definition of turbidity	2. Turbidity defined An expression of the optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample.
	3. Samples should be agitated to re-suspend particles which have settled out.

Module No:	Module Title: Turbidity
	Submodule Title: Visual Method
Approx. Time: 0.25 hours	Topic: Candle Turbidimeter

Instructional Objective:

Upon completion of this module the participant should be able to:

1. List the parts of the candle turbidimeter and their function.
2. Describe precautions to be observed in operating or maintaining the turbidimeter.
3. Relate calibration in Jackson Turbidity Units to length of light path.

Instructional Aids:

Transparency Tu2 - Diagram of candle turbidimeter.

Instructional Approach:

Lecture, demonstration.

References:

Standard Methods pp. 135 - 137.

Class Assignments:

Module No: Tu	Topic: Candle Turbidimeter

Instructor Notes:	Instructor Outline:
Transparency Tu-2 Diagram of turbidimeter	1. Parts of turbidimeter a. Calibrated glass tube to hold sample b. spring-loaded candle support c. bees wax candle 2. Precautions a. clean glassware b. uniform flame c. enclose glass tube in metal tube d. rapidly settling debris 3. As the length of the light path(depth of liquid in tube) decreases the JTU increases to 1000 at 2.3 cm.

Module No:	Module Title: Turbidity
	Submodule Title: Visual Method
Approx. Time: 0.25 hours	Topic: Bottle Standards

Instructional Objective:

Upon completion of this module the participant should be able to:

1. Prepare standard turbidity samples from kaolin clay or natural waters.
2. Measure the turbidity of the standards.
3. Dilute the standards and calculate the Jackson Turbidity Units according to the degree of dilution.

Instructional Aids:

Instructional Approach:

Laboratory Practice

References:

Standard Methods pp. 135 - 137.

Class Assignments:

Module No: Tu	Topic: Bottle Standards
Instructor Notes:	Instructor Outline:

1. For standard use natural water
   a. For Range 5-1000 JTU, dilute and use bottle comparison
   b. dissolve 5 g Kaolin in 1 liter H_2O allow to settle, draw off supernatant and measure with turbidimeter.

2. Pour sample in tube until image of candle just disappears. Level of sample at this point is JTU.

3. If a sample has a JTU of 200 and .50 ml of clear water are added to 10 ml of the sample, the JTU of the diluted sample would be 33.3.

Module No:	Module Title: Turbidity
	Submodule Title: Visual Method
Approx. Time: 0.5 hours	Topic: Comparison and Report of JTU.

Instructional Objective:

Upon completion of this module the participant should be able to:

1. Determine the turbidity of water sample.
2. Compare the turbidity of a sample with Jackson Turbidity Units 5-100 with standard samples in bottles.
3. Determine the JTU of the sample from comparison.

Instructional Aids:

Instructional Approach:

Laboratory practice

References:

Standard Methods p. 137.

Class Assignments:

Module No: Tu	Topic: Comparison and Report of JTU
Instructor Notes:	Instructor Outline:

1. The turbidity of a water sample may be determined directly from the depth at which the flame image disappears or for more dilute samples.

2. By comparison with bottle standards. The standard which best matches the turbidity of the sample will have the same JTU as the sample.

3. The turbidity of the dilute sample is equal to that of the diluted standard.

$$\text{JTU(diluted standard)} = \text{JTU(conc. std.)} \times \frac{\text{total volume}}{\text{volume diluted}}$$

Module No:	Module Title: Turbidity
	Submodule Title: Nephelometric Method
Approx. Time: 0.5 hours	Topic: Choice of Method

Instructional Objective:

Upon completion of this module the participant should be able to:

1. Explain the physical difference in the Nephelometric and Visual comparison methods.
2. Explain which methods should be used under different conditions.

Instructional Aids:

Transparency Tu3 - Principles of measurement

Surface water analysis videotape

Instructional Approach:

Lecture/ discussion

References:

Standard Methods, p. 131, 132, 135.

Class Assignments:

Module No: Tu	Topic: Choice of method

Instructor Notes:	Instructor Outline
Surface video tape	1. Show video tape(first part) answer questions.
Transparency Tu-3 Principles of measurement	2. Nephelometric method measures reflected light and has greater sensitivity. Visual method measures absorbed and reflected light. Light not transmitted.
	3. Method of choice a. slightly turbid: Nephelometric b. very turbid: visual comparison

Module No:	Module Title: Turbidity
	Submodule Title: Nephelometric Method
Approx. Time: 0.5 hours	Topic: Preparation of Standards

Instructional Objective:

Upon completion of this module the participant should be able to:

1. Prepare a stock standard turbidity sample.
2. Dilute the turbidity standard and calculate the turbidity of the diluted standard.

Instructional Aids:

Transparency Tu4 - Steps in preparing standards.

Instructional Approach:

Laboratory practice

References:

Standard Methods p. 133

Class Assignments:

Module No: Tu	Topic: Preparation of Standards - Nephelometric

Instructor Notes:	Instructor Outline:
Transparency Tu-4 Steps in preparing standards 400 NTU Standard: Solution I: 1g $(NH_2)_2 \cdot H_2SO_4$ per 100 ml Solution II: 10g hexamethylene-tetramine per 100 ml Mix 5 ml solution I, 5 ml solution II Allow to stand 24 hours and dilute to 100 ml with distilled water	1. Standard with 400 NTU should be prepared prior to session. 40 NTU standard obtained by dilution of 100 ml 400 NTU solution to 1000 ml. 2. Prepare calibration curve if necessary by dilution to 100 ml of 80, 60, 40, 20 ml of 40 NTU stock to yield standards of 32, 24, 16, 8.

Module No:	Module Title: Turbidity
	Submodule Title: Nephelometric Method
Approx. Time: 0.25 hours	Topic: Turbidimeter Operation

Instructional Objective:

Upon completion of this module the participant should be able to:

1. Operate a turbidimeter and determine the turbidity of a sample in the range of the instrument from a calibrated scale.
2. Determine the turbidity of a sample using an uncalibrated scale and a calibration curve.
3. Dilute a sample with turbidity greater than 40 NTU to obtain a sample on scale.

Instructional Aids:

Transparency Tu5 - Instructions for turbidimeter

Instructional Approach:

Laboratory practice.

References:

Standard Methods p. 134

Operating Instructions

Class Assignments:

Module No: Tu	Topic: Turbidimeter Operation
Instructor Notes:	Instructor Outline:
Transparency Tu-5 Turbidimeter Operation	1. Refer to manufacture's operating instruction for calibration and measurement procedures. If the scale is calibrated, check calibration with 40 NTU standard, insert sample and read NTU directly.
Set up unknowns of turbidity 10-40 NTU and > 40 NTU have students determine turbidity of each.	2. If scale is uncalibrated, measure deflection of each standard, deflection of sample, draw calibration curve and deduce NTU from the curve. 3. If the sample has a NTU greater than 40, dilute sample, determine turbidity of dilute sample.

Module No:	Module Title: Turbidity
Approx. Time: 0.5 hours	Submodule Title: Nephelometric Method
	Topic: Calculation of Results

Instructional Objective:

Upon completion of this module the participant should be able to:

1. Calculate the final turbidity of a water sample greater than 40 NTU.
2. Explain why NTU cannot be directly correlated to JTU.

Instructional Aids:

Instructional Approach:

Lecture, discussion

References:

Standard Methods p. 134.

Class Assignments:

Module No: Tu	Topic: Calculation of Results
Instructor Notes:	Instructor Outline:
	1. $NTU = \frac{NTU(dil) \times (Final\ volume)}{(original\ volume)}$ 2. Difference in methods: a. visual method measures light not transmitted b. nephelometric method measures light reflected at 90° c. depending on particle size, shape, color, etc. the effect of reflection and non-transmission may be different.

Exam Questions

Turbidity
Visual Method
Water Clarity

1. Which of the following is a source of turbidity in water?
   a. suspended matter
   b. color
   c. odor
   d. dissolved substances

2. An expression of the optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample is a definition of _____.

3. To prevent the suspended matter from settling a water sample should be _____ prior to turbidity measurement.

Candle Turbidimetry

4. In the Jackson turbidimeter, what is used to illuminate the sample?

5. What should be done to the wick of the candle to maintain uniform size and distance from the bottom of the glass tube?

6. The longer the light path the larger/smaller(choose one) the JTU value.

Standards

7. Name two sources of turbidity standards.

8. How is the turbidity of the standards determined?

9. A turbid water sample(10 ml) is diluted to 100 ml with non-turbid water. The original sample has a JTU of 300. What is the JTU of the diluted sample?

Comparison and Report of J.T.U.

10. What is the range of turbidities that can be determined directly with the candle turbidimeter?

11. What visual comparison method should be used between 5 and 100 JTU?

12. Are bottle standards more or less sensitive than the candle turbidimeter?

Nephelometric Method
Choice of Method

13. The visual comparison method measures scattered and absorbed light; the nephelometric method measures _____ light only.

14. The _____ method is more sensitive of the two: visual comparison and nephelometric.

15. A nephelometric turbidity standard is prepared from hexamethylene-tetramine and _____.

16. The stock turbidity standard has an NTU of 400; 10 ml of it is diluted to 100 ml. What is the NTU of the diluted standard?

Turbidimeter Operation

17. True or False: A calibration curve needs to be prepared for a turbidimeter with a calibrated scale.

18. True or False: A calibration curve needs to be prepared for a turbidimeter without a calibrated scale.

19. If a sample has a turbidity greater than 40 N.T.U.'s what should be done to it?

20. A 10 ml turbid sample is diluted to 100 ml. The diluted sample has a turbidity of 35 N.T.U. Calculate the turbidity of the non-diluted sample.

21. Why can NTU not be directly correlated to J.T.U.?

TURBIDITY

EQUIPMENT AND SUPPLIES LIST

1. kaolin clay
2. 1 liter volumetric flask
3. 10 - 1 liter bottles
4. Jackson candle turbidimeter with calibrated tubes
5. 100, 50, 25, 10, 5 ml pipets
6. hydrazine sulfate
7. hexamethylene tetramine
8. 5 - 100 ml volumetric flasks
9. distilled water
10. turbidimeter calibrated in 0-40 NTU
11. analytical balance

Turbidity

Laboratory Procedure

I. Standard and reagent preparation

A. Obtain the supplies, equipment, and chemicals listed in the equipment hand-out.

B. Kaolin Turbidity Standard

1. Add 5.0 g kaolin to 1 liter distilled water, shake to mix in in a 1 liter bottle and allow to stand for 24 hours. Withdraw the liquid portion without disturbing the sediment.

2. Measure the turbidity of the standard with a candle turbidimeter. Gradually add the standard to the turbidimeter tube until the image of the candle disappears. Remove the tube and measure the water level corresponding to the JTU calibration on the tube. Report the JTU of the standard (A).

3. Calculate the number of ml (D) needed to produce standards containing 100, 50, 25, 10, 5 JTU. Let the desired JTU value be called B. Then $D = \frac{B \times 1000}{A}$. Add this volume to uniform 1 liter bottles. Add sufficient distilled turbidity-free water to make 1000 ml total.

4. Prepare further dilutions in the range of the sample.

C. Preparation of Nephelometric standard.

1. Solution I. Add 1.000 g (analytical balance) hydrazine sulfate $[(NH_2)_2 - H_2SO_4]$ to a 100 ml volumetric flask, dilute to the mark with distilled water. Mix to dissolve.

2. Solution II. Add 10.00 g hexamethylenetetramine, $(CH_2)_6N_4$ to a 100 ml volumetric flask. Add distilled water to the mark. Mix to dissolve.

3. Add 5.0 ml solution I and 5.0 ml solution II to a 100 ml volumetric flask with a pipet. Mix. Allow to stand 24 hours at room temperature. Dilute to the mark and mix.

4. Pipet 10 ml solution in 3. into a 100 ml volumetric flask. Dilute to the mark. Mix. This solution will be used to calibrate the 40 NTU reading on the nephelometer.

II. Measurement of turbidity

A. Jackson candle turbidimeter method.

Trim the wick and light the candle of the turbidimeter. Insert the tube into the turbidimeter and observe the flame image. Pour

the shaken sample into the glass tube until the candle flame disappears. Remove the tube and record the liquid level calibrated in JTU on the tube.

B. Bottle comparison

Pour 100 ml of the sample into a 1 liter bottle like the ones used for standards. Make dilutions of the standards as in IB3 above. These dilutions should be in the range of the sample. Record the turbidity of the sample as that of the standard which produces the visual effect most closely approximating that of the sample.

C. Nephelometric method.

1. Calibrate the turbidimeter by inserting turbidity free water into the sample compartment and setting zero on the scale. Insert the 40 NTU standard and set 40 on the scale(full scale).

2. Insert the sample container which holds the sample into the sample compartment and read NTU of the sample directly.

D. If dilutions must be made in any case above, dilute to range and measure turbidity of diluted sample. The turbidity of the original is: $[Ax(B+C)]/C$, where: A:NTU found in diluted sample, B=volume dilution water, C=sample volume taken for dilution. Comment on any dilutions made and any other irregularities or sources of error.

Turbidity

Data Sheet

Sample number_____

Visual Comparison Method

JTU of kaolin standard _____JTU = A

Ml needed for 1 liter bottle standards of:

100 JTU = 100x1000/A = _____

50 JTU = 50x1000/A = _____

25 JTU = 25x1000/A = _____

10 JTU = 10x1000/A = _____

5 JTU = 5x1000/A = _____

B_1 JTU = B_1x1000/A = _____

B_2 JTU = B_2x1000/A = _____

B_3 JTU = B_3x1000/A = _____

B_4 JTU = B_4x1000/A = _____

JTU of sample by candle Turbidimeter _____JTU

JTU of further diluted bottle standards:

B_1 = _____JTU B_2 = _____JTU

B_3 = _____JTU B_4 = _____JTU

JTU of sample by bottle comparison _____JTU

Nephelometric Method

NTU of sample _____NTU

Comments:

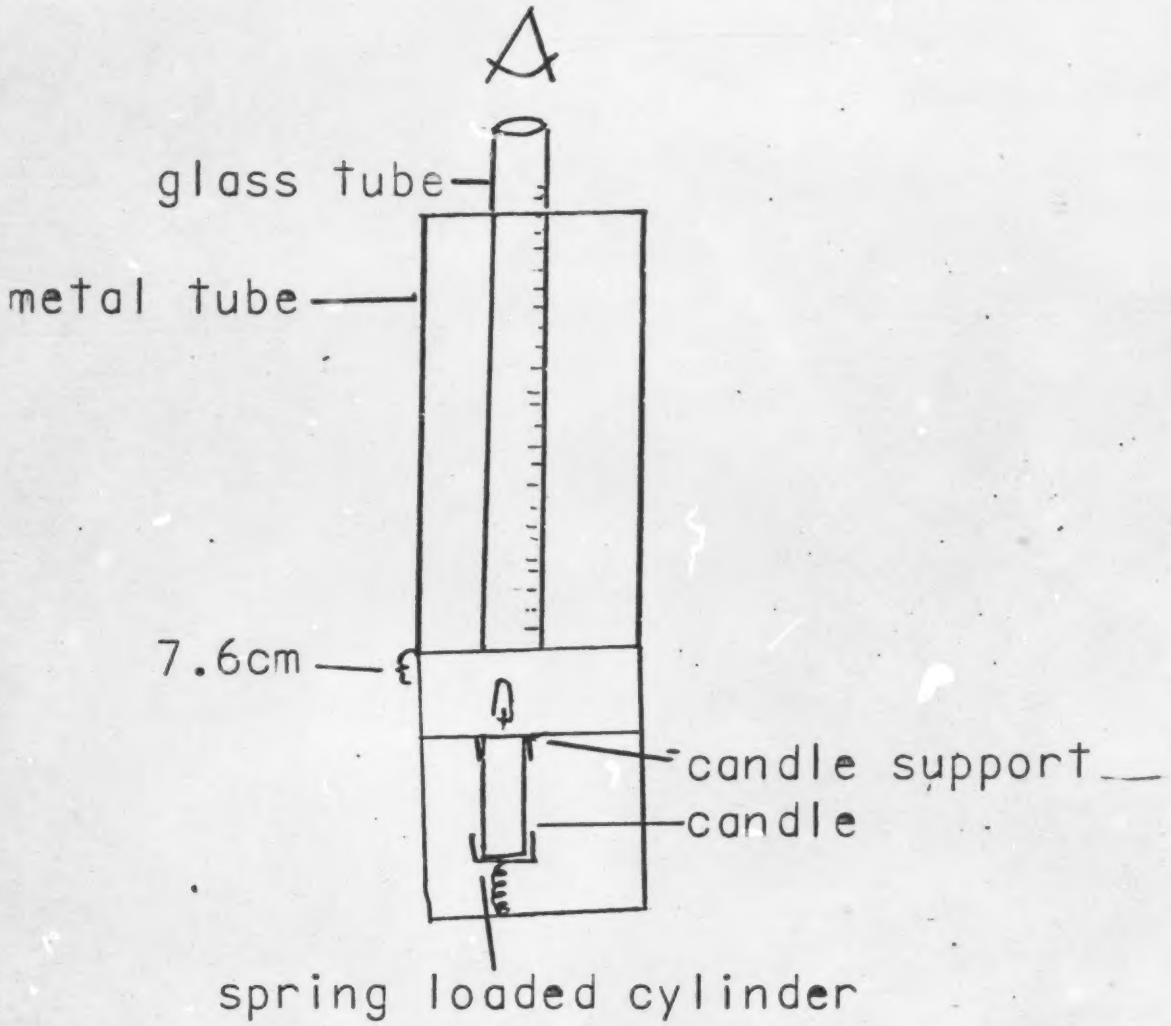
Analyst_____ Date_____

TRANSPARENCY TUI

Definition of Turbidity

An expression of the optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample.

TRANSPARENCY TU2
Diagram of Candle Turbidimeter



TRANSPARENCY TU3
Principles of measurement

1. Nephelometric

   a. more dilute samples

   b. measures scattered light only

2. Visual comparison

   a. high turbidity

   b. measures light not transmitted

TRANSPARENCY TU4

Preparation of Standards

A. 400 NTU Standard
   1. Solution I, 1g $(NH_2)_2 \cdot H_2SO_4$ in 100 ml H_2O.

   2. Solution II, 10g $(CH_2)_6N_4$ in 100 ml H_2O.

   3. Mix 5 ml solution I with 5 ml solution II. Dilute to 100 ml with H_2O.

B. 40 NTU standard
   Dissolve 10 ml 400 NTU standard in H_2O to 100 ml.

TRANSPARENCY TU5

Turbidimeter instructions

1. Calibrated scale
   a. Check calibration of scale with 40 NTU standard and turbidity-free water
   b. Insert sample; read NTU directly.

2. Non- calibrated scale
   a. Measure deflection of each standard (10,20,30,40 NTU)
   b. Plot scale deflection vs. NTU for calibration curve.
   c. Insert sample; measure scale deflection.
   d. Determine NTU by comparison on calibration curve.